AN EVALUATION OF AQUATIC ECOSYSTEM ENHANCEMENT AT FOUR MOUNTAINTOP MINING/VALLEY FILL SITES IN WEST VIRGINIA

Introduction

The purpose of this report is to present the results of an assessment conducted at four (4) mountaintop mining/valley fill sites in southwestern West Virginia. The assessment focused on evaluating: 1) the effectiveness of current mining and reclamation practices relative to minimizing adverse impacts to stream ecosystems; and 2) the potential for improving current practices to mitigate for unavoidable adverse impacts. The assessment is a component of the Interagency Environmental Impact Statement Technical Study. The assessment involved conducting on-site tours of the four mountaintop mining/valley fill sites, reviewing information/data provided by the mining companies, collecting additional information/data on-site through interviews with mining company staff and field observations of current practices, and photographically documenting those field observations. This assessment did not include detailed monitoring, surveys or field data collection. Information for some sites was unavailable or nonexistent. Where little or no information was available on pre-mining and post-mining conditions the evaluation was based on information gathered from the research literature and field observations. Consequently, the findings may reflect potential, rather than actual differences between pre-mining and post-mining conditions.

Background Information

No information or data is available that characterizes the pre-mining conditions at the four mountaintop mining/valley fill sites. Therefore, the following background information is presented to provide a baseline for comparison to existing conditions. Since the four sites evaluated are all located in the Western Appalachian Plateau physiographic province of West Virginia, the information presented focuses on characteristics of stream ecosystems in this region.

First and second order watersheds/streams and the higher order systems, of which they are an integral component, are dynamic units in the landscape. Within these units the entire complex of interacting physical, chemical and biological processes operate to form a fairly self-supporting ecosystem. Key structural components of these ecosystems include physical characteristics of the watersheds and streams draining them, biological communities, and energy and material resources. Functional components included the physical, chemical and biological processes that affect long-term stability and govern the flow of energy and material through the ecosystems.

First and second order watersheds in the Western Appalachian Plateau are generally characterized by steep, V-shaped valleys. Elevational relief is high, with ridges reaching elevations up to 2000 feet and valley floors situated 400 – 600 feet lower in elevation. The down-valley slopes of these watersheds are often greater than 10% and adjacent hillslopes exceeding 50% are not uncommon. The stream systems exhibit a dendritic pattern. Since the region is a plateau there is no general trend to valley aspect.

Land cover is typically deciduous forest. Depending on historical land use practices, the typical structure of these forests includes a canopy layer of mature trees, an understory layer of smaller trees, a shrub layer, and a groundcover layer. The soil of the forest floor is usually covered with a layer of humus or leaf litter. Although soils may be thinner and/or less permeable in some areas, under these forested conditions organic material, soil microorganisms, and plant roots tend to increase soil porosity and permeability, and stabilize soil structure thereby increasing infiltration rates.

As a consequence of high infiltration rates stream baseflows are fairly reliable, except under drought conditions. Interception of precipitation in the forest canopy, high evapotranspiration rates, and soil condition serve to maintain relatively low surface runoff rates during storm events. Forest cover, litter and the presence of lower vegetation also moderate soil microclimate, in particular the depth and frequency of soil frost. Thus infiltration may occur even during the colder months. The higher infiltration rates and lower runoff rates tend to moderate storm discharge volumes in-channel except during larger, less frequent storm events (RI: 50 – 100 YRS). In lower reaches where valley floors are wider, floodplains have developed. These areas serve to detain floodwaters that overtop the channel banks, thereby extending the time of concentration and moderating the effects of these flows on downstream reaches. In some watersheds these floodplain areas support wetland communities, particularly where groundwater discharges at the base of hillslopes.

Due to vegetative cover, stable soil structure, and low runoff rates, soil erosion and sediment transport from upland areas is minimal. The stabilizing effect of vegetation and moderate storm flow volumes result in relatively small inputs of sediment from in-channel sources as well.

The morphologic characteristics of stream channels in these first and second order watersheds vary in confinement, slope, bed features, and bed materials. Steeper reaches are characterized as a cascading or step-pool morphology with irregularly spaced drops and scour pools. The spacing of these features is highly irregular and is controlled by bedrock and large woody debris (LWD). These channels are entrenched (< 1.4) and confined between adjacent hillslopes. Width/depth ratios are low (< 12). Channel gradient can range 4% to 10+%. These channels are relatively straight with sinuosities less than 1.2. Reaches with these characteristics correspond to the A and Aa+ stream types presented in A Classification of Natural Rivers (Rosgen, 1994).
Moderate gradient reaches, 2-4%, usually exhibit riffle-scour pool or rapid-scour pool morphology. At the steeper end of this gradient range they may transition into step-pool morphology. These reaches are characterized by moderate entrenchment (1.4 – 2.2) and a wider valley floor. The valley floor will function as a floodplain for storm flows greater than bankfull and may support wetland communities. Width/depth ratios greater than 12. Channel sinuosity is not high (1.1 – 1.5) but is greater than the A stream types. These channels correspond to B stream types (Rosgen, 1994). Flatter gradient reaches (i.e., less than 2%) are usually not entrenched and may have a well developed floodplain that supports wetland communities. Width to depth ratios are high (> 12). Sinuosity is also higher (1.2 – 2.1) than the steeper A and B stream reaches. These channels correspond to C stream types (Rosgen, 1994). Channel materials in the Aa+, A, B and C stream types vary depending on the lithography of the watershed. In this region headwater reaches most commonly exhibit boulder or cobble beds with lesser amounts of gravels, sands or silts. Bedrock reaches are interspersed throughout. The geometry and dimensions of these channels have been shaped and maintained by the bankfull discharges that occur on roughly an annual basis (RI: 1 – 2 YRS). As indicated previously, the volume of these storm flows is moderated by the forested conditions typical of these watersheds.

The physicochemical properties (e.g., temperature, pH, dissolved gases, and dissolved and suspended organic and inorganic compounds) of the water flowing in these streams are influenced by many factors. In headwater streams, weathering and dissolution of rock is commonly the major determinant of stream water chemistry. However, land use is also a significant factor. For example, in forested watersheds reduced insolation moderates the diel and annual range and seasonal minimum-maximum stream temperatures. Water temperature, in turn, affects the solubility of dissolved gases and solids, as well as the rate of chemical reactions. Litterfall and the decomposition of plant and animal material in forested watersheds are a source of inorganic nutrients that are transported to the stream via throughflow of infiltrated rain and groundwater discharge.

In headwater streams, it is generally recognized that allochthonous material (i.e., leaves, needles, and woody debris falling or blown into the stream from the adjacent forest) and autochthonous sources (i.e., periphyton) are important sources of simple carbon compounds and that they complement one another seasonally. However, forested stream systems are primarily heterotrophic (i.e., rely primarily on allochthonous material) as an energy source. Although autotrophic production is provided by periphytic diatoms, standing biomass is usually kept low by stream scour, invertebrate grazing, and forest shade. Therefore, the ratio of autotrophic production to heterotrophic respiration (P:R) is low (<1).

Consequently, large particulate shredders (e.g., Trichoptera, Plecoptera, Coleoptera, Diptera) and fine particulate collectors-gatherers (e.g., Ephemeroptera, Chironomidae, and Ceratopogonidae) are co-dominant in the macroinvertebrate community of headwater streams. Periphyton grazers (e.g., Ephemeroptera, Trichoptera, Diptera, Lepidoptera, and Coleoptera) and predators (e.g., Megaloptera, Plecoptera, Trichoptera, and Odonata) make up smaller percentages of this community. Primary production provided by algae and macrophytes and a macroinvertebrate community with a large percentage of collector-filterers (e.g., Trichoptera, Diptera, and Ephemeroptera) are more typically associated with higher order reaches where there is less shade, slower moving water, and fine particulate organic matter is transported in suspension. Fish species in these headwater streams are generally those adapted to cold or cool, swift flowing water, with moderately high – high dissolved oxygen concentrations. Benthic invertebrate feeders and too a lesser extent piscivores are the most representative trophic guilds of the fish community.

To contribute energy to the food web of the stream reach, organic material (i.e., leaves, needles, twigs) must be retained in the channel where it can be processed. Therefore, retention and export determine the contribution of organic matter to the stream system. Small headwater stream systems are generally efficient at retaining coarse particulate organic material (CPOM) and processing it to fine particulate organic matter (FPOM) and dissolved organic matter (DOM). Interstices in the streambed and roughness elements, such as boulders and large woody debris in the channel, promote retention. Export of organic matter depends on the hydraulic power of the stream, size of the particle, and retentive capacity of the channel.

Methodology

The first part of the assessment involved the evaluation of current practices relative to minimization of adverse impacts to the stream ecosystems via avoidance or mitigation (i.e., restoration or replacement of structure and function). Evaluating complex natural systems and the effects of alterations to one or more of their components is a difficult task. Although the limitations outlined in the *Introduction* precluded a more detailed assessment, to the extent practical a number of considerations were incorporated into the evaluation process. Based on the characterization of first and second order watersheds/stream ecosystems presented in the *Background Information* a number of relevant questions were postulated. The answers to these questions are presented as findings in this report.

1. Are the watershed/valley characteristics consistent with pre-mining conditions?
2. Is the vegetative cover consistent with pre-mining conditions?
3. Have the soil characteristics been modified?
4. Has the hydrologic regime been altered?
5. Has the sediment regime been modified?
6. Is channel morphology consistent with a natural, stable channel form?
7. Have the physicochemical properties of the streams been altered?
8. Have the biotic communities, trophic structure, and energy sources of the stream ecosystems changed?

Although not included in this evaluation, these same questions should be posed relative to the degree to which current mining and reclamation practices have altered or maintained the natural (pre-mining) structure and function of the higher order watershed/stream ecosystems to which these sites drain.

The second part of the assessment involved identifying opportunities for modifying current practices or implementing new approaches that would minimize the adverse impacts of the mining operations. These are presented as recommendations in this report.

Assessment Results

1. Elk Run Coal Company
East of Stollings Surface Mine

a. General

This mine is located south of the town of Racine, West Virginia. The site has been mined since 1987. The operations on this site consist of surface mining of ridge tops with shovel and truck and loader. The streams draining the site include first and second order tributaries to Mudlick Fork and Stollings Fork, which are part of the Laurel Creek/Big Coal River/Kanawah River drainage system. The mining operation will produce approximately 250 million cubic yards of overburden. Roughly 34.8% (86.2 million cubic yards) of that material will be disposed of in the seven (7) proposed valley fills. The valley fills are composed of durable rock fill built in 50 to 100 foot lifts.

Stormwater runoff conveyance and sediment control are provided for via a network of perimeter sediment ditches, groin ditches, and sedimentation ponds. This network is designed to convey all storm flows up to and including the 100-year runoff event and sediment that is eroded and transported from exposed surfaces. The perimeter ditches collect and convey stormwater flow across the face of the valley fill. Although the dimensions of the ditches vary with drainage area, they are usually constructed on 20 - 30 foot wide benches and have a relatively flat gradient. They are stabilized with a grass mix. Groin ditches convey stormwater flow down the face of the valley fill. They are usually 10 – 15 feet wide. Although breaks in slope occur at the benches where the perimeter ditches contribute their flow, the groin ditches are generally very steep. Groin ditches are lined with large rock to provide stabilization. Sedimentation ponds are constructed at the base of the valley fill to capture and retain sediment transported off the exposed valley fill or active mining areas. The ponds are sized to manage the entire valley fill area. Since baseflow from the streams buried beneath the valley fill discharges into the ponds they retain a permanent pool. The ponds outfall immediately upslope from the receiving streams, Mudlick Fork and Stollings Fork.

b. Evaluation of Current Practices

1. Watershed/Valley Characteristics

The watershed impacted by Valley Fill #3 provides an example of how the mining operation and reclamation will alter the watershed/valley characteristics at this site. The pre-mining difference in elevational relief from the ridgelines to the valley floors was fairly significant. The elevations of the ridgelines ranged from 1800 - 1900 feet while the elevation of the valley floor at its confluence with Mudlick Fork was 1150 feet, an elevational difference of as much as 750 feet. The watershed is being reconstructed with flat or broadly rounded ridgelines, lower in elevation, and a broad valley floor, higher in elevation. Consequently, the elevational difference between the ridgelines and new valley floor will be 100 – 150 feet

Although the overall valley slope of the watershed was greater than 10%, pre-mining the down-valley profile included areas of varying slopes. Some valley reaches were very steep, while other reaches had a fairly gentle slope. Current reclamation practices have created a down valley slope that is uniformly moderate (4%) along the top of the fill and uniformly steep (80%) down the face of the fill.

The pre-mining cross-section of the valley also exhibited variability. Hillslopes were characterized by natural breaks where the form and gradient of the slopes changed from steep and convex to relatively gentle and concave and back to steep and convex. As pointed out above, ridgelines have been constructed to recreate the natural landform. Unfortunately this effort falls short across the top of the valley fill and down the face of the fill, where form is still linear and slopes uniform.

These modifications have reduced the size of the drainage area. The drainage pattern will be altered and more closely resemble a modified trellis. Although the watershed will still trend northwest southeast, its aspect relative to the prevailing winds, precipitation, and insolation will be altered due to the changes in valley form.

2. Vegetative Cover

On this site all vegetation was cleared and grubbed prior to the mining operation commencing. Reclaimed areas were seeded with a grass mix, which included K-31. A few areas have been sparsely planted with one or two species of trees. However, at the time of the tour most stabilized areas were covered with grasses and a few widely scattered volunteer shrubs. The remnant forests on site were isolated on undisturbed hillslopes adjacent to sedimentation ponds along Mudlick Fork and Stollings Fork, and as yet unmined ridgelines.

3. Soil Characteristics

The valley fill is a durable rock fill laid down in lifts. The native topsoil and subsoil layers were removed as part of the mining operation. They were not separated and stockpiled for reuse during reclamation. The material laid down during reclamation is a coarse mixture of rock and other overburden material (e.g., sandstone, limestone, clay, shale, subsoils). This valley fill material has a very high percentage of mineral soil and very low percentage of organic matter. As such it will make a very poor growth medium for reestablishing a forest. No information was available regarding its permeability or infiltration rates. However, since this unconsolidated material is composed of varying types of rock and soil, it is likely that some areas will be permeable and other areas impermeable. Another factor affecting the permeability of this material is mechanical compaction of the fill surface by heavy equipment.

4. Hydrologic Regime

In the areas toured it appeared that baseflows are still flowing along the old valley floor, emerging at the base of the valley fill into the sedimentation ponds. The perimeter sediment ditches and groin ditches carry flow during and immediately after storm events. There is no baseflow in these channels. Although no data was available relative to the volume and time of concentration of storm flows, based on the characteristics of the fill material, compaction of the fill surface, and a relatively sparse vegetative cover, it is likely that the volume of runoff is significantly greater than under pre-mining conditions. It is also likely that the time of concentration for these flow events has been reduced with the potential to effect downstream reaches. The perimeter ditches and sedimentation ponds help detain runoff and may provide some management for the increased runoff.

5. Sediment Regime

No data was available to allow a quantitative comparison of erosion and sediment transport rates. However, it is likely that erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are significantly higher than pre-mining conditions. However, it appears that disturbed areas routed to the perimeter ditch/groin ditch/sedimentation pond systems are being managed effectively thereby limiting actual sediment loadings to the receiving streams. Erosion of channel bed and banks in receiving streams adjusting to increased storm flows could provide an unmanaged source of sediment to downstream reaches.

6. Channel Morphology

Based on a review of the site map provided, it appears that approximately 10,500 feet of the first and second order streams on site have been permanently impacted by valley fill. Another 3500 feet of stream channel has been temporarily impacted for construction of access roads, and sedimentation ponds.

The morphology of the perimeter ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The perimeter ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep (80%). There are no discernible bed features (i.e., step-pools or riffle-pools). Since the channels are designed to convey runoff from larger storm events all flows are confined to that one channel. Consequently, there are no natural channels with typical baseflow and bankfull channels and an adjacent floodprone bench or floodplain. However, it should be noted that the constructed channels appeared to be stable and functioning as designed.

7. Physicochemical Properties

The Elk Run Coal Company collected water quality data in the Spring, Summer, and Fall of 1999. Although that data was unavailable for this assessment, water quality data collected from streams draining similar surface mining/valley fill operations may apply to this site. On the sites they were monitoring, Maggard and Kirk (1998) found that several water quality parameters varied from pre-mining levels. Their data indicates that conductivity, total dissolved solids, hardness, alkalinity, sulfates, sodium, calcium, and magnesium levels had increased significantly.

R.E.I. Consultants, Inc. (1999) evaluated the water quality of sedimentation ponds constructed on similar mining sites. They found that water quality varied considerably with the age of the facilities. For example, pH ranged from 5.04 - 8.77, in newer and older ponds respectively. They reported that most of the chemical values (e.g., dissolved solids, hardness, alkalinity, sulfates, and most metals) were initially fairly high, diminishing somewhat with the age of the structure. Their data may apply to the ponds on this site.

8. Biotic Communities, Trophic Structure, and Energy Sources

The Elk Run Coal Company collected biological data in the Spring, Summer, and Fall of 1999. Although that data was unavailable for this assessment, biological data collected from streams draining similar surface mining/valley fill operations may apply to this site. On the sites they monitoring, Maggard and Kirk (1998) found that the benthic macroinvertebrate community downstream of mining/valley fill operations shifted toward more pollution tolerant species. Their data indicates that the number of individuals and taxa richness increased, while diversity and evenness decreased.

R.E.I. Consultants, Inc. (1999) evaluated the biological communities in sedimentation ponds constructed on other similar mining sites. They found that the biotic communities developing in the sedimentation ponds include species typical of a lentic ecosystem. Macrophytes and filamentous algae provide primary production. Allochthonous material enters these sites as litterfall from forests on adjacent hillslopes.

The benthic macroinvertebrate community is composed of typical pond species (e.g., Diptera, Coleoptera, Hemiptera, Odonata, and Oligochaeta). The communities in the newer facilities exhibited low abundance and diversity, and were represented predominantly by very pollution tolerant species. The older facilities, where water quality was better and vegetation was abundant, exhibited higher abundance and diversity. Species present were still primarily pollution tolerant organisms. The fish community was not represented in the ponds. In the short-term at least, it is not likely that these structures will provide habitat for amphibians since most amphibian species are very sensitive to poor water quality.

Elk Run Coal Company's East of Stollings Surface Mine

Looking across valley fill toward active mining area.

Active mining area with adjacent reclaimed area. Photo taken from valley fill looking toward sedimentation pond.

Older (pre-1994) reclaimed area. Valley fill with groin ditch to perimeter ditch.

More recent (post-1994) reclaimed area. Valley fill with perimeter ditches and groin ditches to convey runoff from slopes.

Active valley fill with perimeter ditches across face of fill.

Sedimentation ponds at base of valley fill. Photo shows undisturbed slopes on both sides and perimeter ditch in fill to left.

Groin ditch to perimeter sedimentation ditch in older area.

Photo shows sedimentation ditch at older site.

Outfall control structure for sedimentation ditch

2. Catenary Coal Company Samples Surface Mine

a. General

This mine is located near the town of Eskdale, West Virginia. Catenary Coal Company acquired the site in 1989 and the current expansion commenced in 1993. The operations on this site consist of dragline surface mining of ridge tops. The streams draining the site include first and second order tributaries to Cabin Creek and White Oak Creek/Big Coal River, which are in the Kanawah River drainage system. In 1998 the mining operation moved 80 million bank cubic yards of material. Roughly 25% (20 million loose cubic yards) of that material was disposed of in valley fills. The valley fills are composed of durable rock fill built in 50 to 100 foot lifts.

Stormwater runoff conveyance and sediment control are provided for via a network of combination ditches, groin ditches, and sedimentation ponds. This network is designed to convey all storm flows up to and including the 100-year runoff event and sediment that is eroded and transported from exposed surfaces. The combination ditches collect and convey stormwater flow across the top of the valley fill. The combination ditches are 10 – 15 feet wide across the bottom and have a relatively flat gradient. They were stabilized with a grass mix. Groin ditches convey stormwater flow down the face of the valley fill. They are usually 10 – 15 feet wide. Although breaks in slope occur at the benches, the groin ditches are generally very steep. Groin ditches are lined with large rock to provide stabilization. Sedimentation ponds were constructed at the top and base of the valley fill to capture and retain sediment transported off the exposed valley fill or active mining areas. The ponds are sized to manage the entire area draining to them. Some of the ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. Where this baseflow discharges into the sedimentation ponds they retain a permanent pool.

c. Evaluation of Current Practices

1. Watershed/Valley Characteristics

The pre-mining difference in elevational relief from the ridgelines to the valley floors was fairly significant. The surface mining/valley fill significantly reduced the elevational difference between the original ridgelines and valley floors. However, contour/landform grading and backstacking of overburden to heights of 300 feet has restored some of the relief and recreated ridgelines.

Although the overall valley slope of the watershed was greater than 10%, pre-mining the down-valley profile included areas of varying slopes. Some valley reaches were very steep, while other reaches had a fairly gentle slope. Current reclamation practices have created a down valley slope that is uniformly moderate along the top of the fill and uniformly steep down the face of the fill.

The pre-mining cross-section of the valley also exhibited variability. Hillslopes were characterized by natural breaks where the form and gradient of the slopes changed from steep and convex to relatively gentle and concave and back to steep and convex. As pointed out above, ridgelines have been constructed to recreate the natural landform. Unfortunately this effort falls short across the top of the valley fill and down the face of the fill, where form is still linear and slopes uniform.

These modifications have reduced the size of the drainage area. The drainage patterns have been altered and more closely resemble a modified trellis. As result of the changes in landform, the watershed aspect relative to prevailing winds, precipitation, and insolation has been altered.

2. Vegetative Cover

On this site all vegetation was cleared and grubbed prior to the mining operation commencing. Reclaimed areas were seeded with a grass mix, which included K-31. A few areas have been sparsely planted with one or two species of trees. However, at the time of the tour most stabilized areas were covered with grasses and a few widely scattered volunteer shrubs. The remnant forests on site were isolated on undisturbed hillslopes adjacent to downstream reaches and unmined ridgelines.

3. Soil Characteristics

The valley fill is a durable rock fill laid down in lifts. The native topsoil and subsoil layers were removed as part of the mining operation. They were not separated and stockpiled for reuse during reclamation. The material laid down during reclamation is a coarse mixture of rock and other overburden material (e.g., sandstone, limestone, clay, shale, subsoils). This valley fill material has a very high percentage of mineral soil and very low percentage of organic matter. As such it will make a very poor growth medium for reestablishing a forest. No information was available regarding its permeability or infiltration rates. However, since this unconsolidated material is composed of varying types of rock and soil, it is likely that some areas will be permeable and other areas impermeable. Another factor affecting the permeability of this material is mechanical compaction of the fill surface by heavy equipment.

4. Hydrologic Regime

Some of the combination ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. In the areas toured the baseflows are maintaining a permanent pool in sedimentation ponds and supporting wetland vegetation around the margins of the pond and in the ditches. Reclamation of the Kayford Refuse Pile along Tenmile Fork was completed in 1999. This reclamation included construction of a series of ponds, artificial wetland systems, and a channel that conveys baseflow and stormflow.

Although no data was available relative to the volume and time of concentration of storm flows, based on the characteristics of the fill material, compaction of the fill surface, and a relatively sparse vegetative cover, it is likely that the volume of runoff is significantly greater than under pre-mining conditions. It is also likely that the time of concentration for these flow events has been reduced with the potential to effect downstream reaches. The combination ditches and sedimentation ponds help detain runoff and therefore may be providing some management for the increased storm flows.

5. Sediment Regime

No data was available to allow a quantitative comparison of erosion and sediment transport rates. However, it is likely that erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are significantly higher than pre-mining conditions. However, it appears that disturbed areas routed to the combination ditch/groin ditch/sedimentation pond systems are being managed effectively thereby limiting actual sediment loadings from the site to the receiving streams. Increased storm flows from the site could contribute to channel adjustment and instability of downstream reaches, thereby creating a potential source of uncontrolled sediment.

6. Channel Morphology

No information was available to determine the linear feet of stream channel impacted by the valley fills. However, given the size of the fill areas observed on site it appears that major sections (i.e., several miles) of the first and second order streams on site have been impacted by valley fill or the construction of the sedimentation ponds.

The morphology of the combination ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The perimeter ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep. The one combination ditch observed during the tour along the top of the fill appeared to be developing discernible bed features (i.e., riffle and pools). However, since the channels are designed to convey runoff from larger storm events all flows are confined to that one channel. Consequently, there are no bankfull channels with an adjacent floodplain. It should be noted that the engineered channels constructed along the top and down the face of the valley fill appeared to be stable and functioning as designed.

The channel constructed at the Kayford Reclamation site is also an engineered channel. It has two distinct reaches. The upper reach starts at the base of the large sedimentation pond. This reach is wide, trapezoidal, relatively flat and entrenched. It appeared to be lined with a geotextile erosion control fabric. Given its dimensions, it is obviously designed to carry fairly significant storm flows. Unfortunately, because it is entrenched there is no floodplain surface to convey the high flows. During high flows channel velocities and shear stresses will be considerable. This situation could affect the long-term stability of the reach. The lower reach is also wide and trapezoidal, but very steep. This section is lined with geotextile fabric and rock. During the tour of this area, it was observed that the bed of the lower reach is incising immediately downstream of the break in slope between the upper and lower reach and a headcut is eroding into the upper reach. This unstable condition is probably the result of a number of interrelated factors, including the unusually high shear stresses generated through the entrenched upper reach and at the point where the slope suddenly increases at the upstream end of the lower reach, the morphology of the channel in the steep reach, the size of rock used to stabilize the reach, and flow eroding material from beneath the fabric. The natural reach immediately downstream exhibited heavy sedimentation. If not corrected, the headcut will continue upstream, destabilizing the upper reach.

7. Physicochemical Properties

Although no water quality data was available for this assessment, Maggard and Kirk (1998) monitoring streams draining similar mining/valley fill operations found that several water quality parameters had varied from pre-mining levels. Their data indicates that conductivity, total dissolved solids, hardness, alkalinity, sulfates, sodium, calcium, and magnesium had increased significantly. Their findings may apply to the receiving streams on this site.

R.E.I. Consultants, Inc. (1999) evaluated the water quality of sedimentation ponds constructed on similar mining sites. They found that water quality varied considerably with the age of the facilities. For example, pH ranged from 5.04 - 8.77, in newer and older ponds respectively. They reported that most of the chemical values (e.g., dissolved solids, hardness, alkalinity, sulfates, and most metals) were initially fairly high, diminishing somewhat with the age of the structure. These findings may apply to the ponds on this site.

8. Biotic Communities, Trophic Structure, and Energy Sources

No biological data was available for this assessment. However, Maggard and Kirk (1998) monitoring streams below similar mining/valley fill operations found that the benthic macroinvertebrate community shifted toward more pollution tolerant species. Their data indicates that the number of individuals and taxa richness increased, while diversity and evenness decreased. These findings may apply to the tributaries of Cabin Creek and White Oak Creek.

R.E.I. Consultants, Inc. (1999) evaluated the biological communities in sedimentation ponds constructed on similar mining sites. The biotic communities that have developed in these facilities include species typical of a lentic ecosystem. Macrophytes and filamentous algae provide primary production. Allochthonous material enters these sites as litterfall from forests on adjacent hillslopes.

The benthic macroinvertebrate community is composed of typical pond species (e.g., Diptera, Coleoptera, Hemiptera, Odonata, and Oligochaeta. The communities in the newer facilities exhibited low abundance and diversity, and were represented predominantly by very pollution tolerant species. The older facilities, where water quality was better and vegetation was abundant, exhibited higher abundance and diversity. Species present were still primarily pollution tolerant organisms. The fish community was not represented in the ditches and ponds. It is not likely that these structures will provide habitat for amphibians since most amphibian species are very sensitive to poor water quality.

Ditch draining upper sedimentation pond.

Ditch draining upper sedimentation pond

On-line sedimentation pond downstream of valley fill

Concrete spillway of on-line sedimentation pond

Wetland ponds downstream of sedimentation pond. Photo shows runoff ditch to right of wetland ponds. This ditch conveys baseflow and stormflows.

Runoff ditch along right valley wall adjacent to wetland ponds

Headcut erosion at break in slope at downstream end of runoff ditch

Headcut erosion working upstream through steep section of runoff ditch

Heavy sedimentation in receiving stream below runoff ditch

Heavy sedimentation in receiving stream below runoff ditch

3. Pen Coal Corporation
Kiah Creek Mine

a. General

This mine is located near the town of Ferrellsburg, West Virginia. The operations at this site consist of ridgetop and contour surface mining utilizing truck and loader methods. The streams draining the site include first and second order tributaries to Vance Branch of Trough Fork and Rollem Fork of Kiah Creek, which are part of the East Fork of Twelvepole Creek drainage system. The mining operation will produce approximately 360 million cubic yards of overburden. Approximately 25% (9 0 million cubic yards) of that material will be disposed of in the proposed valley fills. The valley fills are composed of durable rock fill built in 50 to 100 foot lifts.

Stormwater runoff conveyance and sediment control are provided for via a network of combination ditches, groin ditches, and sedimentation ponds. This network is designed to convey all storm flows up to and including the 100 year runoff event and sediment that is eroded and transported from exposed surfaces. The combination ditches collect and convey stormwater flow around the perimeter of the valley fill. Although the dimensions of the ditches vary with drainage area, they are commonly constructed with 10 - 15 foot bottom widths and 6 – 8 foot depth. They have a relatively flat gradient and stone weirs are spaced regularly along the ditches to improve sedimentation rates. The ditches are stabilized with a grass mix. Groin ditches convey stormwater flow down the face of the valley fill. They are usually 10 – 15 feet wide. Although, breaks in slope occur at the benches where the perimeter ditches contribute their flow, the groin ditches are generally very steep. Groin ditches are lined with large rock to provide stabilization. Sedimentation ponds are constructed on the benches along the valley fill and at the base of the valley fill to capture and retain sediment transported off the exposed valley fill or active mining areas. The ponds are sized to manage the entire disturbed area. Some of the ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. Where this baseflow discharges into the sedimentation ponds they retain a permanent pool. In other areas baseflow from the streams buried beneath the valley fill discharges into the ponds providing a permanent pool. Such is the case with the ponds that outfall immediately upslope from the receiving streams, Vance Branch and Rollem Fork.

d. Evaluation of Current Practices

1. Watershed/Valley Characteristics

In the areas toured the majority of the operations were contour mining. Ridgetop mining made up only a small percentage of the overall mining activity. Consequently, the amount of valley fill and disturbance to ridgelines was significantly less than observed on other mining sites where ridgetop mining made up the larger percentage of the operations.

The pre-mining difference in elevational relief from the ridgelines to the valley floors was fairly significant. In areas of ridgetop mining/valley fill the elevational difference between the original ridgelines and valley floors fill have been significantly reduced. Contour grading and backstacking of overburden has restored some of the relief.

Although the overall valley slope of the watershed was greater than 10%, pre-mining the down-valley profile included areas of varying slopes. Some valley reaches were very steep, while other reaches had a fairly gentle slope. In the valley fill areas, current reclamation practices have created a down valley slope that is uniformly moderate along the top of the fill and uniformly steep down the face of the fill.

The pre-mining cross-section of the valley also exhibited variability. Hillslopes were characterized by natural breaks where the form and gradient of the slopes changed from steep and convex to relatively gentle and concave and back to steep and convex. Reconstructed landform is still predominantly linear on this site.

2. Vegetative Cover

On this site clearing and grubbing of vegetation was mostly restricted to the areas to be mined. Consequently, the undisturbed ridgelines and hillslopes above and below the areas of contour mining are still heavily forested. Recently reclaimed areas along Vance Branch and Rollem Fork were seeded with a grass mix and appeared to have a dense grass cover. Some unmined valley floor areas were cleared to accommodate construction of access roads, sedimentation ponds, relocation of the stream channel, and floodplain fill. These areas were seeded with a grass/clover mix and appeared to have a dense grass cover.

A reclamation site along Frank's Branch was toured to observe a reforestation effort that was completed 10 years ago. One area appeared to be progressing very well. In addition to the initial plantings, it was evident that volunteer species were doing well. This has probably increased overall diversity of this early-successional vegetative community. The overall vegetation was dense enough, even without foliage, to make it difficult to determine the location of the groin ditch routed down the face of the valley fill. Interestingly, an area immediately adjacent on the same slope had experienced rill and gully erosion immediately after reclamation. The area had been repaired, stabilized with a grass mix (that included K-31) and reforested. Although, the two areas were the same age, this slope area was still covered in grass with only a few widely scattered shrubs.

3. Soil Characteristics

The valley fill is a durable rock fill laid down in lifts. The native topsoil and subsoil layers were removed as part of the mining operation. They were not separated and stockpiled for reuse during reclamation. The material laid down during reclamation is a coarse mixture of rock and other overburden material (e.g., sandstone, limestone, clay, shale, subsoils). This valley fill material has a very high percentage of mineral soil and very low percentage of organic matter. Because this material makes a very poor growth medium for reestablishing a forest a 6-inch layer of topsoil is added overall reclaimed areas. No information was available regarding permeability or infiltration rates of the valley fill material. However, Mr. Randy Maggard (personal communication) characterized this unconsolidated material as a "psuedo-karst" landscape, composed of varying types of rock and soil that will be permeable in some areas and impermeable in others. Another factor affecting the permeability of the fill material is mechanical compaction of the fill surface by heavy equipment.

4. Hydrologic Regime

Some of the combination ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. These ditches support wetland vegetation. The baseflows are also maintaining a permanent pool in all the sedimentation ponds observed. Many of the ponds exhibited a dense growth of wetland vegetation around their margins. Although no data was available relative to the volume and time of concentration of storm flows, based on the characteristics of the fill material, compaction of the fill surface, and a relatively sparse vegetative cover, it is likely that the volume of runoff is significantly greater than under pre-mining conditions. It is also likely that the time of concentration for these flow events have been reduced with the potential to affect downstream reaches. The combination ditch/groin ditch/sedimentation pond systems help detain runoff and therefore may be providing some management for the increased storm flows.

5. Sediment Regime

No data was available to allow a quantitative comparison of erosion and sediment transport rates. However, it is likely that erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are significantly higher than pre-mining conditions. However, it appears that disturbed areas routed to the combination ditch/groin ditch/sedimentation pond systems are being managed effectively thereby limiting actual sediment loadings to the receiving streams. Erosion of the stream bed and banks in areas that adjust to accommodate the increased storm flow volumes provides a potential unmanaged source of sediment to downstream reaches.

6. Channel Morphology

Based on a review of the site maps provided, it appears that approximately 8000 linear feet of first and second order streams were permanently impacted by valley fill in the Rollem Fork area. Another 3200 linear feet stream channel (and adjacent floodplain) of Rollem Fork have been temporarily impacted for the construction and maintenance of the sedimentation ponds. It is important to note that the contour mining operations on this site have significantly reduced the potential impact on the Rollem Fork system relative to the impacts observed at other sites where ridgetop mining operations dominate.

The morphology of the combination ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The combination ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep. There are no discernible bed features (i.e., riffle-pools) in the combination ditches. However, several of the groin ditches appeared to be developing a step-pool morphology. Since the channels are designed to convey runoff from larger storm events all flows are confined to that one channel. They were not designed to have a baseflow, and bankfull channel with and adjacent floodplain. It should be noted that the constructed channels appeared to be stable and functioning as designed.

7. Physicochemical Properties

Pen Coal Company at their mining sites has collected stream and pond water quality data. Although no stream data was available for the sites evaluated in this assessment, Maggard and Kirk (1998) monitoring streams draining other Pen Coal mining sites found that several water quality parameters had varied from pre-mining levels. Their data indicates that conductivity, total dissolved solids, hardness, alkalinity, sulfates, sodium, calcium, and magnesium had increased significantly. These trends in water quality may apply to the receiving streams on this site as well.

R.E.I. Consultants, Inc. (1999) evaluated the water quality of combination ditches and sedimentation ponds constructed in the Vance Branch, Rollem Fork, and the Left Fork of Parker Branch drainage basins. Water quality varied considerably between the sampling sites. For example, pH ranged from 5.04 - 8.77 in the ponds and from 5.32 – 9.39 in the combination ditches. They found that most of the chemical values (e.g., dissolved solids, hardness, alkalinity, sulfates, and most metals) were high. They found that water quality improved with the age of the structure.

8. Biotic Communities, Trophic Structure, and Energy Sources

Pen Coal Company has collected a considerable amount of stream and pond biological data at their mining sites. Although no stream data was available for the sites evaluated in this assessment, Maggard and Kirk (1998) found that the benthic macroinvertebrate communities downstream of mining/valley fill operations shifted toward more pollution tolerant species. Their data indicates that the number of individuals and taxa richness increased, while diversity and evenness decreased. These findings may apply to Rollem Fork and Vance Branch.

R.E.I. Consultants, Inc. (1999) evaluated the biological communities in the combination ditches and sedimentation ponds constructed in the Vance Branch, Rollem Fork, and the Left Fork of Parker Branch drainage basins. The biotic communities that have developed in the combination ditches and sedimentation ponds include species typical of a lentic ecosystem. Macrophytes and filamentous algae provide primary production. Allochthonous material enters these sites as litterfall from forests on adjacent hillslopes.

The benthic macroinvertebrate community is composed of typical pond species (e.g., Diptera, Coleoptera, Hemiptera, Odonata, and Oligochaeta. The communities in the newer facilities exhibited low abundance and diversity, and were represented predominantly by very pollution tolerant species. The older facilities, where water quality was better and vegetation was abundant, exhibited higher abundance and diversity. Species present were still primarily pollution tolerant organisms. The fish community was not represented in the ditches and ponds. It is not likely that these structures will provide habitat for amphibians since most amphibian species are very sensitive to poor water quality.

Combination ditch with ponded baseflow

Outfall of combination ditch. Baseflow has gone subsurface into valley fill.

Combination ditch with baseflow supporting wetland vegetation

Wetland vegetation and filamentous algae in combination ditch

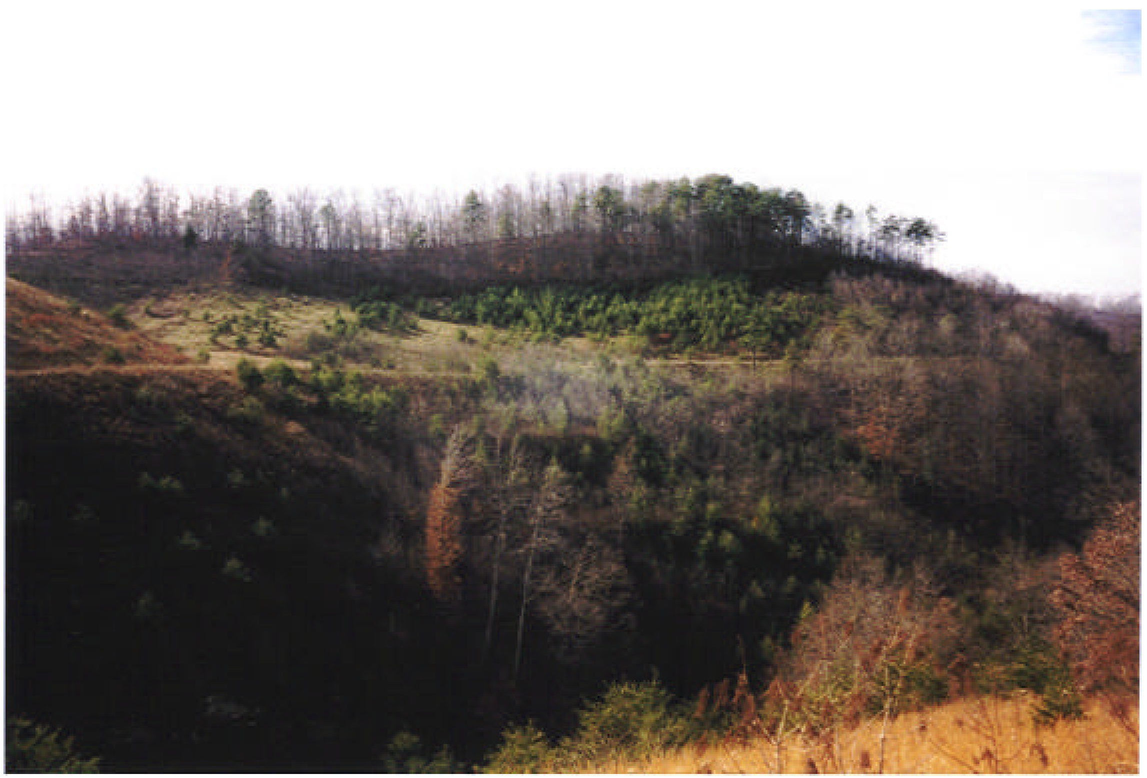
Groin ditches convey storm flow down face of valley fill

Groin ditch from upper sedimentation pond.
Photo shows outfall pipes from pond and early evolution of
"natural" channel within ditch.

Groin ditch into first of lower sedimentation ponds in series

Relocated reach of Rollem Fork.

Photo shows undisturbed forested hillslope to left and floodplain fill to right.



Reforestation of old valley fill along Frank's Branch.

Reforestation of old valley fill.
Groin ditch barely visible in center of photo.

4. Arch Coal Company
Hobet # 21 Mine

a. General

This mine is located near the town of Madison, West Virginia. The operations at this site consist of ridgetop surface mining utilizing walking dragline and electric shovel methods. The streams draining the site include first and second order tributaries to Little Coal River and Mud River which are part of the Guyandotte River Creek drainage system. Approximately 30 -35% of the overburden material removed will be disposed of in valley fills. The valley fills are composed of durable rock fill built in 50 to 100 foot lifts.

Stormwater runoff conveyance and sediment control are provided for via a network of combination ditches, groin ditches, and sedimentation ponds. This network is designed to convey all storm flows up to and including the 100-year runoff event and sediment that is eroded and transported from exposed surfaces. The combination ditches collect and convey stormwater flow around the perimeter of the valley fill. Although the dimensions of the ditches vary with drainage area, they are commonly constructed with 10 - 15 foot bottom widths and 6 – 8 foot depth. They have a relatively flat gradient and stone weirs are spaced regularly along the ditches to improve sedimentation rates. The ditches are stabilized with a grass mix. Groin ditches convey stormwater flow down the face of the valley fill. They are usually 10 – 15 feet wide. Although breaks in slope occur at the benches where the perimeter ditches contribute their flow, the groin ditches are generally very steep. Groin ditches are lined with large rock to provide stabilization. Sedimentation ponds are constructed at points along the combination ditches on top of the valley fill. Although the tour did not include the base of the valley fill presumably ponds have been constructed there as well. This system serves to convey storm runoff and capture and retain sediment transported off the exposed valley fill or active mining areas. The ponds are sized to manage the entire disturbed area. . Some of the ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. Where this baseflow discharges into the sedimentation ponds they retain a permanent pool. In other areas baseflow from the streams buried beneath the valley fill discharges into the ponds providing a permanent pool.

e. Evaluation of Current Practices

1. Watershed/Valley Characteristics

Operations on this site involve surface mining of ridgetops. Consequently, the amount of valley fill and disturbance to ridgelines is significant. The pre-mining difference in elevational relief from the ridgelines to the valley floors was fairly significant. Removal of ridgetops and disposal of overburden in valley fill has significantly reduced the elevational difference between the original ridgelines and valley floors. Contour/landform grading and backstacking of overburden to heights of 100 feet has restored some of the relief and natural landform.

Although the overall valley slope of the watershed was greater than 10%, pre-mining the down-valley profile included areas of varying slopes. Some valley reaches were very steep, while other reaches had a fairly gentle slope. In the valley fill areas, current reclamation practices have created a down valley slope that is uniformly moderate along the top of the fill and uniformly steep down the face of the fill.

The pre-mining cross-section of the valley also exhibited variability. Hillslopes were characterized by natural breaks where the form and gradient of the slopes changed from steep and convex to relatively gentle and concave and back to steep and convex. Reclamation has restored some of the valley cross-section along the ridgelines. Although the valley floor sits much higher in elevation, in some areas there has been an obvious effort to recreate the swale and meander associated with a naturally formed valley floor. The oldest area observed was reclaimed in the early 1980's. Reclamation of this area involved 250 feet of conventional fill with four-foot lifts and a chimney core drain down the center of the valley fill. In this area the valley fill is predominantly linear with a uniform slope.

2. Vegetative Cover

On this site all vegetation was cleared and grubbed prior to the mining operation commencing. Reclaimed areas were seeded with a grass mix. A few areas have been densely planted with one or two species of shrubs and trees.

The new valley floor in the older (1980's) reclamation area is predominantly grasses with scattered shrubs and trees and the adjacent slopes have a fairly good cover of trees. However, the revegetation effort on these slopes has resulted in an even-aged stand that lacks the species diversity and multi-layered vertical structure of a natural forest.

Most of the stabilized areas on site are covered with grasses and a few widely scattered volunteer shrubs. The remnant forests on site were isolated on undisturbed hillslopes adjacent to downstream reaches and unmined ridgelines.

3. Soil Characteristics

The valley fill is a durable rock fill laid down in lifts. The native topsoil and subsoil layers were removed as part of the mining operation. They were not separated and stockpiled for reuse during reclamation. The material laid down during reclamation is a coarse mixture of rock and other overburden material (e.g., sandstone, limestone, clay, shale, subsoils). This valley fill material has a very high percentage of mineral soil and very low percentage of organic matter. This material makes a very poor growth medium for reestablishing a forest. No information was available regarding permeability or infiltration rates of the valley fill material. However, since this unconsolidated material is composed of varying types of rock and soil it is likely that some areas will be permeable and other areas will be impermeable. Another factor affecting the permeability of the fill material is mechanical compaction of the fill surface by heavy equipment.

4. Hydrologic Regime

Some of the combination ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. These ditches support wetland vegetation. The baseflows are also maintaining a permanent pool in all the sedimentation ponds observed. Many of the ponds exhibited a dense growth of wetland vegetation around their margins. Although no data was available relative to the volume and time of concentration of storm flows, based on the characteristics of the fill material, compaction of the fill surface, and a relatively sparse vegetative cover, it is likely that the volume of runoff is significantly greater than under pre-mining conditions. It is also likely that the time of concentration for these flow events has been reduced with the potential to effect downstream reaches. The combination ditch/groin ditch/sedimentation pond systems help detain runoff and may provide some management of the increased storm flows.

5. Sediment Regime

No data was available to allow a quantitative comparison of erosion and sediment transport rates. However, it is likely that erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are significantly higher than pre-mining conditions. However, it appears that disturbed areas routed to the combination ditch/groin ditch/sedimentation pond systems are being managed effectively thereby limiting actual sediment loadings to the receiving streams. Erosion of the stream bed and banks in areas that adjust to accommodate the increased storm flow volumes may provide one unmanaged source of sediment to downstream reaches.

6. Channel Morphology

No information was available to determine the linear feet of first and second order streams permanently impacted by the valley fills. However, given the size of the fill areas observed during the tour the total stream length impacted is probably fairly substantial (i.e., several miles).

The morphology of the combination ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The combination ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep. There are no discernible bed features (i.e., riffle-pools) in the combination ditches. Since the channels are designed to convey runoff from larger storm events all flows are confined to that one channel. They were not designed to have a baseflow and bankfull channel with and adjacent floodplain. It should be noted that the constructed channels appeared to be stable and functioning as designed.

During the tour a combination channel in the Stanley Fork drainage basin was observed. This channel was constructed along the edge of a cut-slope and valley fill on the down dip side of the valley. Completed in 1995, it carries a baseflow and supports wetland vegetation. This drainage system also includes a series of shallow ponds and wetlands. The constructed channel is routed away from the face of the valley fill outfalling instead down an undisturbed forested hillslope. The result of this design has been to initiate the carving of a channel down a slope where none had previously existed. At the time of the tour it was evident that this channel is in its early evolutionary stages and would be characterized as a gully or G stream type (Rosgen, 1994). Although, the upper 200 feet of this reach is relatively stable, the lower sections are very unstable. Scour and degradation of the channel bed is proceeding in a downslope direction as a result of concentrated flows directed over these extremely steep slopes. In addition, a significant headcut was observed eroding upslope. This channel will continue to adjust for some time to come. Eventually it may erode to bedrock. This condition and/or the accumulation of large woody debris (LWD) will arrest the bed degradation and provide vertical control. Lateral adjustment will continue until the channel has carved the dimensions necessary to convey the bankfull and greater storm flows. Until this channel has reached a state of equilibrium it will be a significant source of sediment to downstream reaches. It is not known if this channel represents a common situation on this or other mining sites.

7. Physicochemical Properties

Although no receiving stream water quality data was available for this site, Maggard and Kirk (1998) monitoring streams draining other mountaintop mining/valley fill sites found that several water quality parameters had varied from pre-mining levels. Their data indicates that conductivity, total dissolved solids, hardness, alkalinity, sulfates, sodium, calcium, and magnesium had increased significantly. These trends in water quality may apply to the receiving streams on this site as well.

R.E.I. Consultants, Inc. (1999) evaluated the water quality of combination ditches and sedimentation ponds constructed on other similar mining sites. Water quality varied considerably between their sampling sites. For example, pH ranged from 5.04 - 8.77 in the ponds and from 5.32 – 9.39 in the combination ditches. They found that most of the chemical values (e.g., dissolved solids, hardness, alkalinity, sulfates, and most metals) were high. They found that water quality improved with the age of the structure. Their findings may apply to the water quality of the combination ditches and ponds on this site.

8. Biotic Communities, Trophic Structure, and Energy Sources

Although no receiving stream biological data was available for this site, Maggard and Kirk (1998) found that the benthic macroinvertebrate community downstream of mining/valley fill operations shifted toward more pollution tolerant species. Their data indicates that the number of individuals and taxa richness increased, while diversity and evenness decreased. These findings may apply to the tributaries of Little Coal River and Mud River downstream of this site.

R.E.I. Consultants, Inc. (1999) evaluated the biological communities in the combination ditches and sedimentation ponds constructed on other mining sites. The biotic communities that have developed in the combination ditches and sedimentation ponds include species typical of a lentic ecosystem. Macrophytes and filamentous algae provide primary production.

The benthic macroinvertebrate community is composed of typical pond species (e.g., Diptera, Coleoptera, Hemiptera, Odonata, and Oligochaeta. The communities in the newer facilities exhibited low abundance and diversity, and were represented predominantly by very pollution tolerant species. The older facilities, where water quality was better and vegetation was abundant, exhibited higher abundance and diversity. Species present were still primarily pollution tolerant organisms. The fish community was not represented in the ditches and ponds. In the short-term, it is unlikely that these structures will provide habitat for amphibians since most amphibian species are very sensitive to poor water quality.

Reclaimed area (1990).
Photo shows restored ridgelines, ponds, wetlands, and reforestation.

Recently reclaimed area with restored ridgelines and wetland system on valley fill

Face of recent valley fill

Combination ditch with baseflow

Combination ditch with baseflow. Photo shows wetland vegetation along margins of ditch.

Outfall of combination ditch routed over undisturbed forested hillslope

Gully erosion on forested hillslope. Headcut eroding in an upslope direction.

Summary of Findings

The results of this assessment indicate that current mining and reclamation practices result in significant adverse impacts to the first and second order stream ecosystems on mountaintop mining/valley fill sites. At all four sites evaluated watershed and stream characteristics have been significantly, and in most cases, permanently altered.

The shape, slope, size and aspect of the watersheds and valleys have been altered. Removal of ridgetops and raising of valley floors by disposal of overburden in valley fills have significantly reduced the pre-mining difference in elevational relief between the ridgelines and valley floors. The natural variability characteristic of valley profiles and cross-sections has been replaced with linear landforms and uniform slopes. Reclamation has reduced the size of the drainage area for some sites and enlarged it for others. Drainage patterns have been altered from the characteristic dendritic pattern to one best described as a modified trellis. Although the watersheds have no common aspect or orientation, for some reclaimed sites their original aspect has been modified.

Some sites have incorporated contour/landform grading and backstacking of overburden into their reclamation operations. The results of these efforts were obvious in restored elevational relief and more natural ridgelines. However, the watersheds and valleys are still very different than under pre-mining conditions. Some, perhaps all of these differences have the potential to modify the influence of prevailing winds, precipitation, and insolation on the hydrologic regime, soil characteristics, vegetative communities, and channel morphology which, in turn, effect the physical, chemical and biological characteristics of the stream ecosystem.

The creation of steep uniform slopes, disruption of the native soil and geologic strata by the mining operations, construction of fill surfaces with highly variable permeability, compaction of soils by heavy equipment, and alteration from forest to grassland all serve to modify the hydrologic regime of the sites. The result of these modifications is increased storm flow volumes and decreased time of concentration relative to pre-mining forested conditions. Although, the combination ditch/groin ditch/sedimentation pond systems are designed to convey storm runoff, it is unclear how effective these systems are at actually managing the increased flows and restoring the pre-mining hydrology.

In addition to the effects on hydrology mentioned above, the alterations in soil characteristics make the sites poorly suited for reestablishing forest cover. The soils are very sterile, that is, high in mineral content and low in organic matter content. The unconsolidated nature of the fills results in some areas with extremely high permeability rates typified by droughty soil conditions while other areas that have relatively low permeability rates typified by perched water conditions. Neither situation is conducive to reestablishing a natural forest. Soil conditions will naturally improve with time. However, until suitable soil characteristics redevelop the vegetative cover will be limited to grasses and scattered shrubs. The situation is exacerbated by the lack of potential seed banks adjacent to reclaimed areas on many sites. This situation is due to the complete removal or isolation of mature forests from the reclamation sites. Sites where forested ridgelines or hillslopes are adjacent to reclaimed areas may provide a source of pioneer species. However, without substantial changes to current practices reestablishing natural forest conditions on most of these sites could take as long as 400-500 years (S. Handel, personal communication).

Erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are probably much higher than under pre-mining conditions. The combination ditch/groin ditch/sedimentation pond systems are being managed effectively and limit the actual sediment loadings to the receiving streams. However, erosion of the streambed and banks in areas that adjust to accommodate the increased storm flow volumes provide a potential unmanaged source of sediment to downstream reaches. Two specific problem areas were pointed out in the *Assessment Results* section. The first area involved an entrenched runoff ditch that was experiencing headcut erosion at the break in slope where the channel gradient suddenly increased. The second site involved a combination ditch that had been routed away from the face of the valley fill outfalling down an undisturbed forested hillslope. The results of this situation were even more severe. Scour and degradation of the channel bed is proceeding in a downslope direction and a significant headcut is eroding upslope. Until these channels have been stabilized or naturally evolve to a state of equilibrium they will be significant sources of sediment to downstream reaches. It is not known if these cases represent common situations on surface mining sites.

If the size of the valley fill areas observed during the tour is representative of mountaintop mining/valley fill operations, the total stream length of first and second order streams that could be impacted by current and future surface mining operations is substantial. Utilizing information from these sites it is estimated that approximately 10 linear feet of stream channel are directly and permanently impacted (i.e., buried beneath valley fills) for each acre of surface mining. An additional 3 feet of stream channel are directly and temporarily impacted (i.e., construction of on-line sedimentation ponds) for each acre of surface mining. This equates to 12,000 linear feet (2.27 miles) of permanent impacts and 3600 linear feet (0.68 miles) of temporary impacts or a total of 15,600 linear feet (2.95 miles) of impacts on a 1200-acre surface mining site. These numbers raise two critical questions. Can these impacts be avoided? How can unavoidable impacts be minimized and/or mitigated?

Consideration is being given to mitigating for the adverse impacts to the natural channels on surface mining sites by creating aquatic habitat in the drainage systems (i.e., ditches and ponds) routinely constructed to convey runoff and control sediment eroded from the disturbed areas on site. On a linear foot basis this should be feasible since an equivalent number of miles (or greater) of channel are created in the combination and groin ditches.

The critical issue is whether the constructed drainage systems can mitigate for the impacts to the natural stream ecosystems on the surface mining sites. The results of this assessment provide insight on this issue.

The morphology of the combination ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The combination ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep. There are no discernible bed features (i.e., riffle-pools, step-pools) in the ditches. These ditches were designed to convey runoff from larger storm events with all flows confined to one channel. They were not designed to have a baseflow and bankfull channel and an adjacent floodprone area.

Most of the drainage systems observed during the tour carry storm flow only (i.e., during and immediately following storm events). Only a few sites were observed where these ditches and ponds had been constructed along the edge of a cut-slope and valley fill on the down dip side of the valley. These ditches and ponds do carry a baseflow. Most of these drainage systems support wetland vegetation. The more complex systems include combination ditches and a series of shallow ponds and wetlands.

Although biotic communities have developed in many of the ditches and ponds the species present are typical of lentic ecosystems. Abundance and diversity are low and most species are very pollution tolerant. The structure of the biotic community is in part due to channel morphology (wide, shallow and low gradient) and flow conditions (i.e., slow moving or standing/ponded water). It is also influenced by poor water quality and a lack of vegetation.

Woody vegetation in the riparian zone is sparse or non-existent. No obvious attempts have been made to plant trees or shrubs in these areas. Consequently, macrophytes and filamentous algae provide primary production in these systems.

The results of this assessment indicate that first and second order stream ecosystems are being significantly impacted by mountaintop mining/valley fill operations. Current mining and reclamation practices have not been effective at avoiding or minimizing adverse impacts to these stream ecosystems and aquatic habitat enhancement in the constructed drainage systems does not mitigate (i.e., replace) the natural structure and function of the first and second order stream ecosystems that existed pre-mining. .

Summary of Recommendations

This section focuses on recommended approaches for minimizing and mitigating unavoidable adverse impacts to first and second order stream ecosystems on mountaintop mining/valley fill sites.

1. Modifications to Overburden Disposal and Reclamation Practices

   Current mountaintop mining/valley fill practices involve the removal of overburden from ridgetops to expose the coal seam(s) for mining. The overburden removed is disposed of in the adjacent stream valleys. Valley fill is usually laid down in 50 to 100 foot lifts. The new valley floor (i.e., top of valley fill) may be 400-600 feet above the original valley floor. Generally, lifts are constructed such that the face of successively higher lifts is set back 25-40 feet from the lift immediately below it. This creates a bench of uniform width across the valley fill. Removal of ridgetops and disposal of overburden in valley fill significantly reduces the elevational difference between the original ridgelines and valley floors. In the valley fill areas, current reclamation practices create a down valley slope that is uniformly moderate along the top of the fill and uniformly steep down the face of the fill. The reconstructed landform is predominantly linear and uniform on most sites.

   Landform grading and backstacking of overburden to heights of 200 –300 feet would restore some of the relief and natural landform of the ridgelines. The backstacking to higher elevations would also provide additional upland disposal areas thereby reducing the volume of overburden placed in valley fills. Although millions of cubic yards of overburden material are removed during the mining operation, regulation requires that the bulk (80%) of the material segregated for disposal as valley fill must have been determined to be durable and geochemically suitable. A portion of the overburden removed will be unsuitable for valley fill disposal. It would seem that these requirements would encourage the disposal of overburden material in upland areas as opposed to the valley fills.

   Landform grading and modifying construction practices for the fill lifts could restore the natural form and slope of the valleys. This would involve constructing irregular lifts of varying face height and bench width. For example, a series of 15-foot high lifts with 10 foot wide benches might be followed by a series of 5 foot high lifts with 50 foot wide benches. Lifts could be constructed such that those along the margins of the fill at the interface with the hillslopes extend further out while those toward the center of the valley fill are inset. The left side of a lift could be constructed higher than the right side to provide variable cross-valley slopes.

   Utilizing this approach, valleys could be recreated with a down-valley profile that includes areas of varying slopes. Some valley reaches would be very steep, while other reaches would have moderate or even fairly gentle slope. The variability exhibited by the pre-mining valley cross-section could be restored creating ridgelines and hillslopes with natural breaks where the form and gradient of the slopes change from steep and convex to gentle and concave and back to steep and convex. Although the valley floor would still sit much higher in elevation, the swale and meander associated with a naturally formed valley floor could be recreated.

The characteristics of the fill material itself should be modified. The upper layers must be amended to provide a growth medium suitable for reestablishing a natural forest. This could be accomplished by working in stages. The first stage would involve laying down a layer of mulch and topsoil. The mulch can be prepared from the vegetation cleared and grubbed from a new surface mining site. The topsoil can be salvaged from that same surface mining site as well. After the soil has been prepared it is fertilized and seeded with a grass mix of rye and clovers and native meadow grasses.

To initiate the process of reestablishing a natural forest, a variety of native of tree and shrub pioneering species should be planted on the newly reconstructed ridgelines and hillslopes and along the valley floors, concentrating on the drainage ways. This vegetative community should be established (10-15 years) prior to the introduction of native tree and shrub forest species. Where reclaimed areas are adjacent to undisturbed forests this successional process may be accelerated.

2. Restoration of stream channels and floodplains

Opportunities for restoration of existing streams were harder to identify where ridgetop mining operations were predominant and valley fills had been extensive. For example, removal of on-line ponds from all the tributaries to Mudlick and Stollings Creek at Elk Run's East of Stollings Mine site would recapture approximately 1800 linear feet of stream channel with the two longest individual reaches being less than 500 feet each and the rest ranging from 100 – 250 linear feet. However, on sites where contour mining was predominant and valley fills had not been as extensive a number of restoration opportunities exist. For example, removal of on-line sedimentation ponds, floodplain fill, and sections of access road from Rollem Fork at Pen Coal's Kiah Creek Mine site would recapture approximately 3600 feet of stream channel.

Rollem Fork provides an excellent example for presenting recommendations for restoration of stream channels and floodplains. Rollem Fork appears to have been relocated at some time in the past. Floodplain fill resulting from construction of the pond berms, disposal of sediment removed from the ponds, and construction of the access road has confined the stream between the fill and the adjacent hillslope. This condition has created an entrenched G stream type channel. Woody riparian vegetation is sparse along the fill side of the channel. One restoration approach would involve lowering of the pond berms, and removal of floodplain fill and sections of access road. The existing stream channel should be relocated away from the hillslope and towards the center of the valley floor. This would also provide a floodprone area to accommodate overbank flows. The off-line ponds at the base of valley fill and in the floodplain could be combined and reconstructed as one large freshwater marsh with varying hydrologic regimes (i.e., permanently flooded, seasonally flooded and seasonally saturated). The outfall pipes should be removed. The new outfall to this freshwater marsh/pond would be a small E stream type channel that meanders along the floodplain before emptying into Rollem Fork. The margins and seasonally saturated areas could be planted with trees and shrubs and the flooded areas with emergent vegetation. The riparian zone along both banks of the stream should be heavily planted with native trees and shrubs.

3. Modifications to design of combination ditch/groin ditch/sedimentation ponds

Many of the combination ditches and groin ditches observed convey storm flows only. Most of them appeared to be stable and functioning as designed. Unless baseflow can be diverted to these channels, there is no reason to modify them. Where opportunities exist to capture groundwater and generate a baseflow, the channels should be constructed with natural channel morphology including planform, profile, and cross-sectional geometry. Vertical and horizontal controls and flow diverting structures should be installed to stabilize the channel bed and banks.

The design of these natural channels would include baseflow and bankfull channels and floodprone areas. The channel form should be consistent with that appropriate for the valley type in which they will be constructed. For example, the steeper reaches (i.e., down the face of the fill) of a groin ditch redesigned as a natural stream channel would have the characteristics of an A or Aa+ stream type with a step-pool morphology. The lower gradient reaches (i.e., across the top of the bench) of groin ditches and most combination ditches redesigned as a natural channel would have the characteristics of B, C or E stream types. Selection of the appropriate stream type would be guided by the characteristics of stream types and valley types presented in A Classification of Natural Rivers (Rosgen, 1994) and Applied River Morphology (Rosgen, 1996).

Specific design parameters would be developed utilizing a Natural Channel Design Approach that includes: the use of regional hydrologic and hydraulic geometry curves; channel morphology data obtained from field surveys of stable reference reaches of the same stream type as that determined to be appropriate for the particular on-site situation; vertical bed control provided by boulder and log drop structures, rock sills, cross vanes, etc.; horizontal bank control provided by toe boulders, soil fabric lifts, and dense growth of trees and shrubs along the banks and in the adjacent riparian zone. Flow diverting structures (e.g., rock vanes j-hook vanes, cross vanes, w-weirs, etc.) can take stress off the banks by diverting flows toward the center of the channel. The vertical and horizontal controls and flow diverting structures are installed and key points along the channel. They stabilize the channel bed and banks as well as create and maintain diversity of channel features and habitat. Sedimentation ponds can be redesigned to create shallow marsh and open water habitats in the floodprone areas adjacent to the lower gradient channels (i.e., C and E stream types). Plantings of submerged aquatic, emergent, and woody vegetation would improve water quality and enhance the habitat for benthic macroinvertebrates, amphibians, reptiles and waterfowl. The natural channel design approach has the greatest chance for success if it also incorporates the modifications to valley fill practices presented above.